Value of the interconnectors in the Nordic countries

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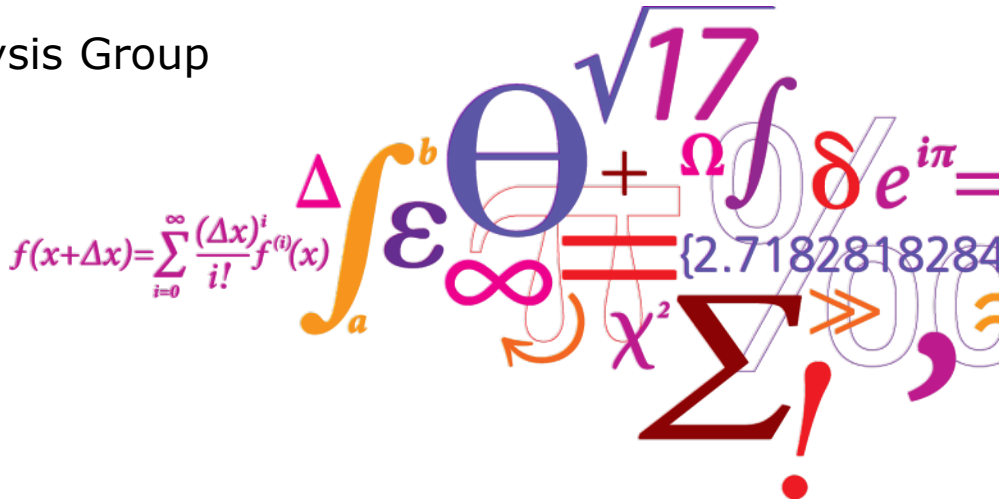

DTU Management Engineering
Department of Management Engineering

Agenda

- Background
- TIMES-NordPool
- Analysis of power trade in the Nordic countries
- Analysis of grid expansion possibilities
- Sensitivity analysis on effect of no grid expansion
- Conclusions

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Background: Nord Pool market

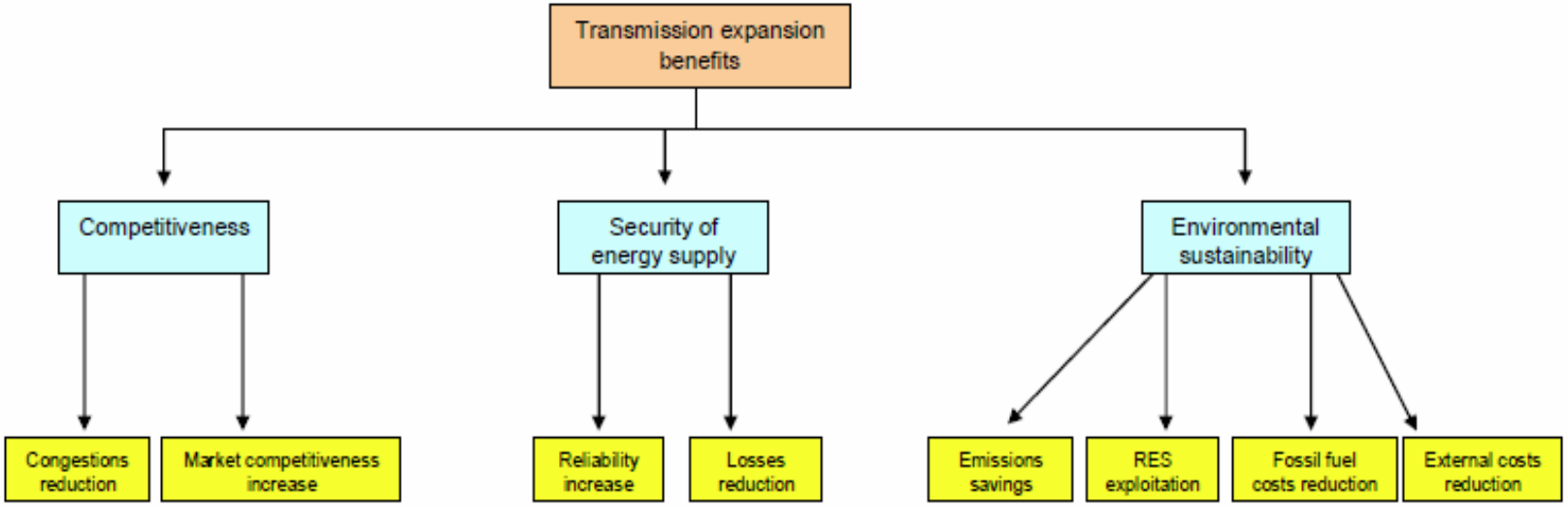
Nord Pool: power trading market of Nordic and Baltic countries.

The auctioning countries are divided into bidding areas linked with interconnectors controlled by the TSOs.

If the power flows between the bidding areas exceed the interconnectors transmission limit, grid congestion occurs.

Bottlenecks in the interconnectors lead to different prices in the various areas composing the Nordic electric system.

Benefits of interconnectors capacity expansion



Source: L' Abbate et al. (2011)

Interconnectors are one of the main power price drivers in the Nordic countries
Interconnectors are essential for the integration of variable power sources

Interesting to assess their role and their influence on the power trade

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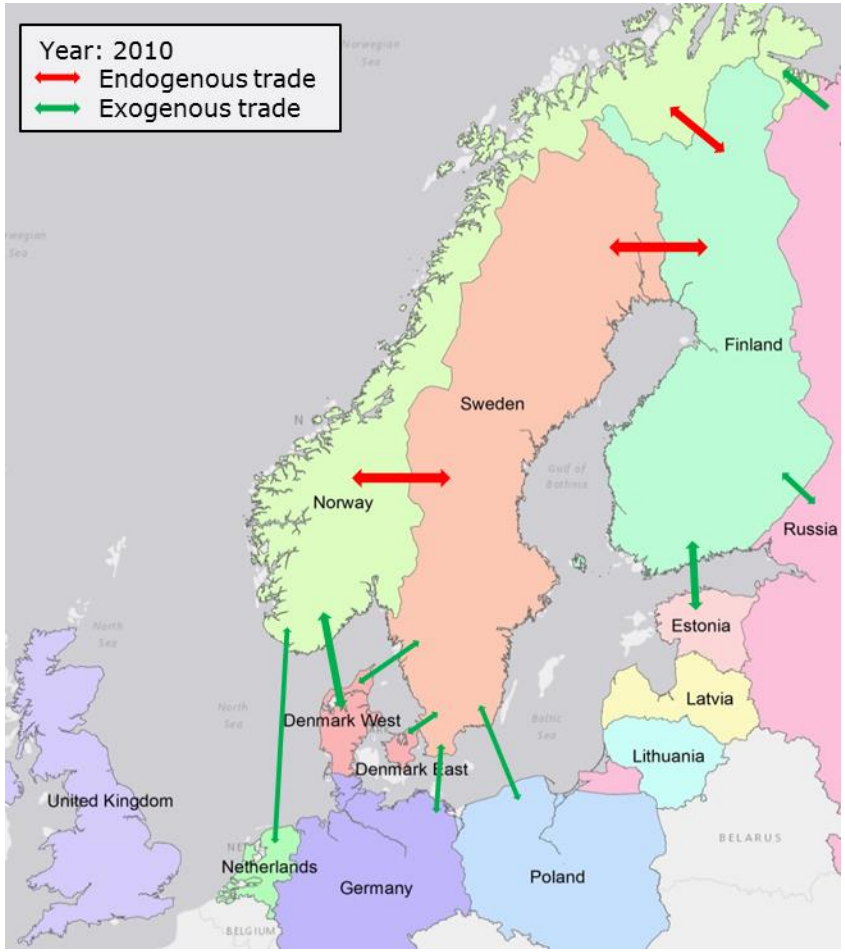
TIMES-NordPool

TIMES-NordPool: represents the Norwegian, Swedish and Finnish power and thermal systems.

Purposes:

- To be run together with TIMES-DK to better simulate power trade processes
- Exploring the future power exchange between the Nordic countries under different assumptions
- Assessing transmission capacity expansion under different scenarios

TIMES-NordPool: Spatial resolution



- Multiregional model: Each country = One region
- Interconnectors between Norway, Finland and Sweden implemented as **endogenous trade processes**

↓

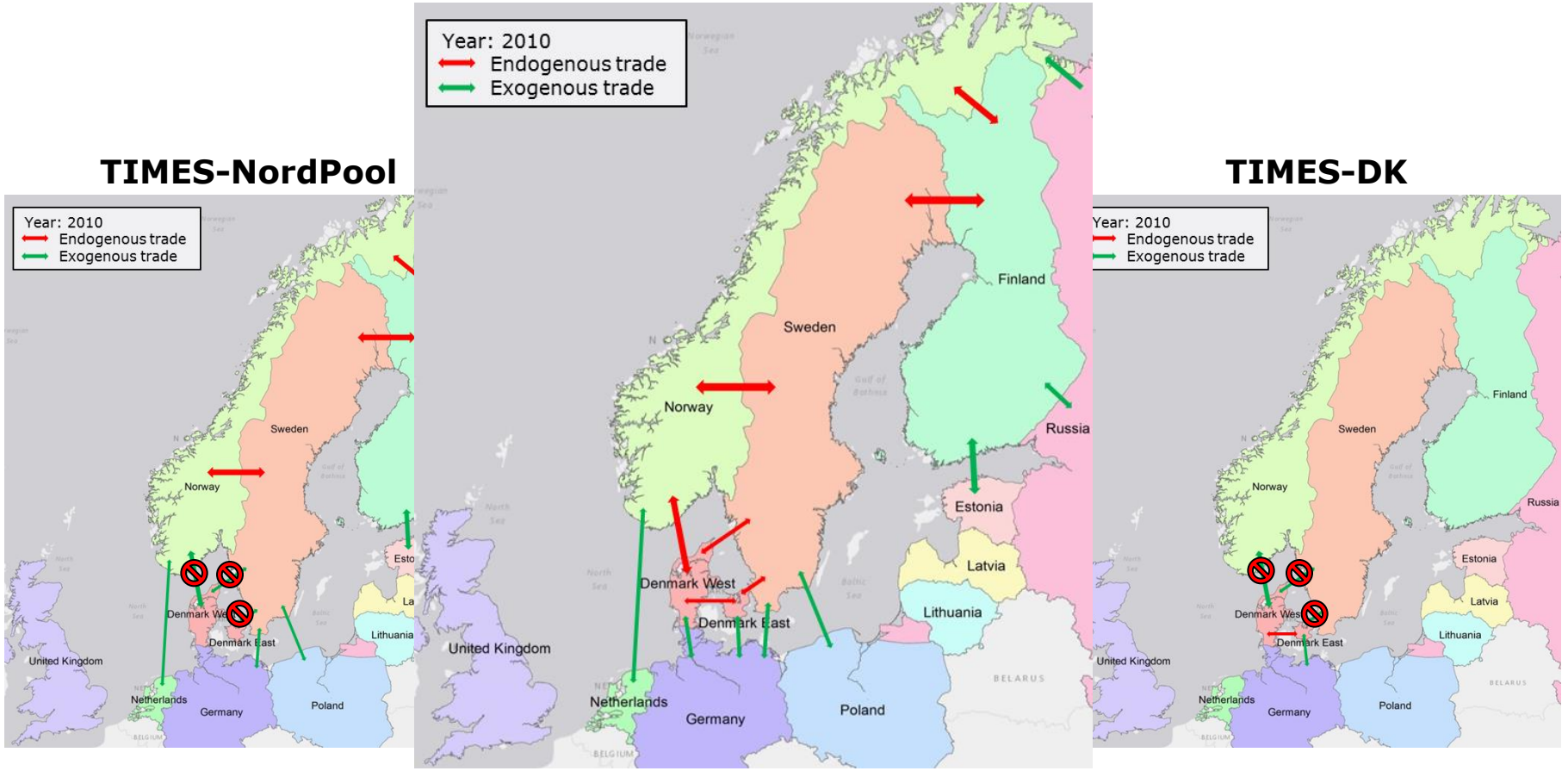
Power prices and volumes endogenously optimized

- Interconnectors between Nordic countries and neighboring countries implemented as **exogenous trade processes**

↓

Power volumes calculated according to price related criteria

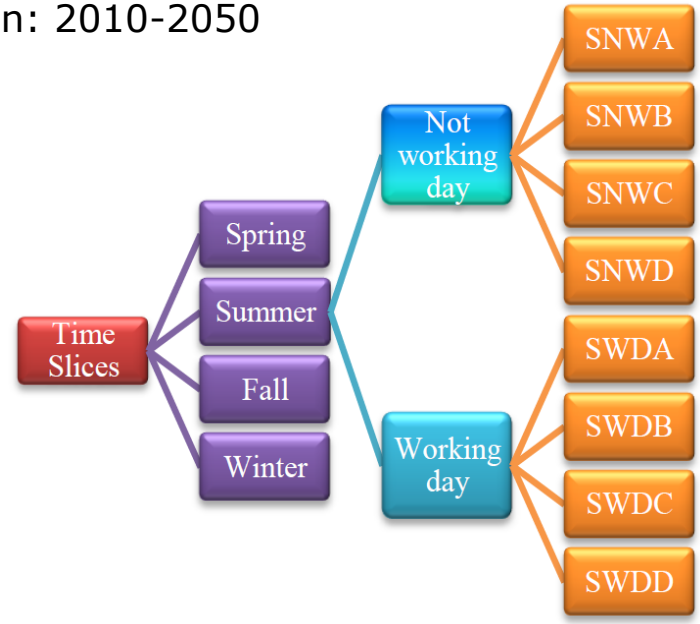
TIMES-NordPool: Hard-linking with TIMES-DK



All interconnections between Nordic countries as endogenous processes

TIMES-NordPool: Time structure

- Same 32 time slices as TIMES-DK ⇨ The models are consistent
- Base Year: 2010
- Time horizon: 2010-2050



SNWA: summer, not working day, high wind availability low power demand

SWDD: summer, working day, rest of hours

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Assumptions for the analysis

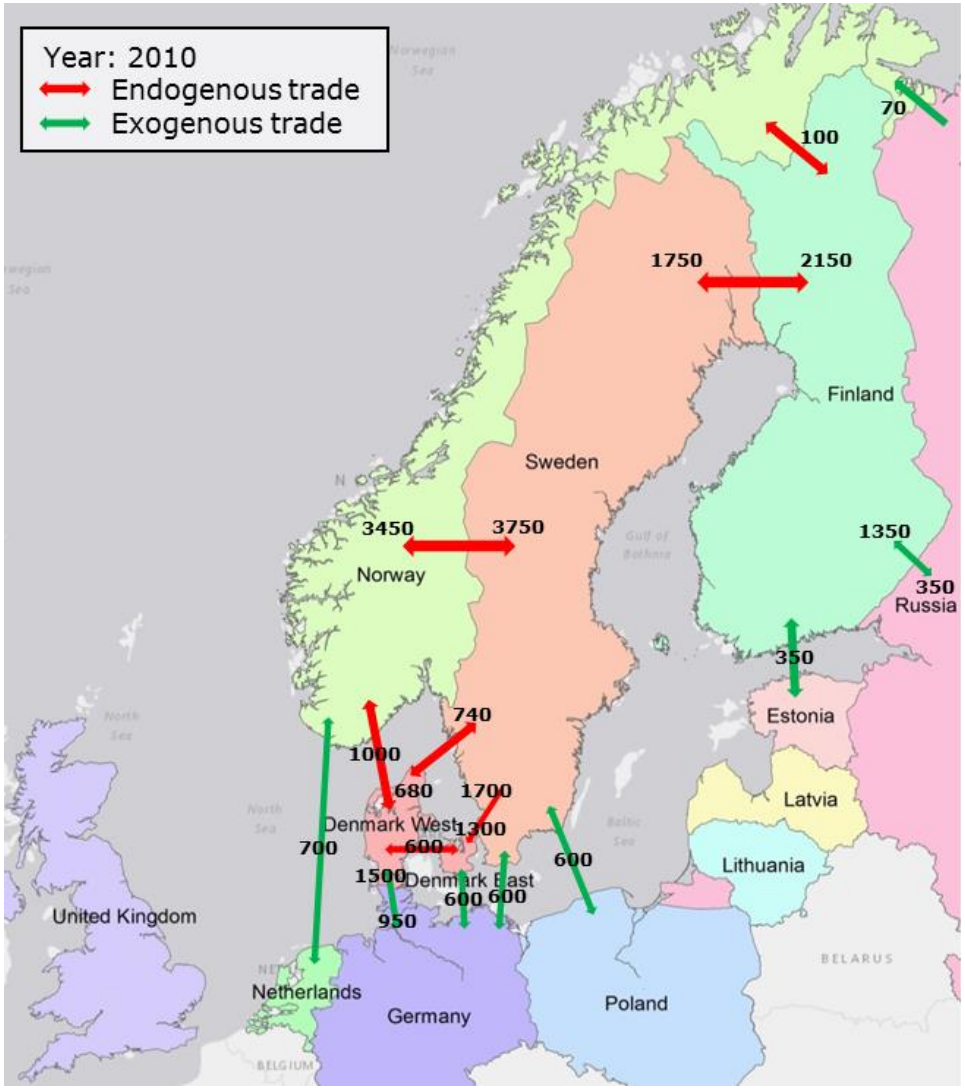
All **analyses** on the power trade between the Nordic countries have been performed using **TIMES-NordPool hard-linked to TIMES-DK.**

Baseline scenario considers:

- DKW and DKE: power and thermal system fossil free by 2035, entire energy system fossil free by 2050
- NOR, FIN, SWE: no environmental constraints (NETP Carbon Neutral scenario is implemented but not activated)

Transmission grid in the base year

Base year

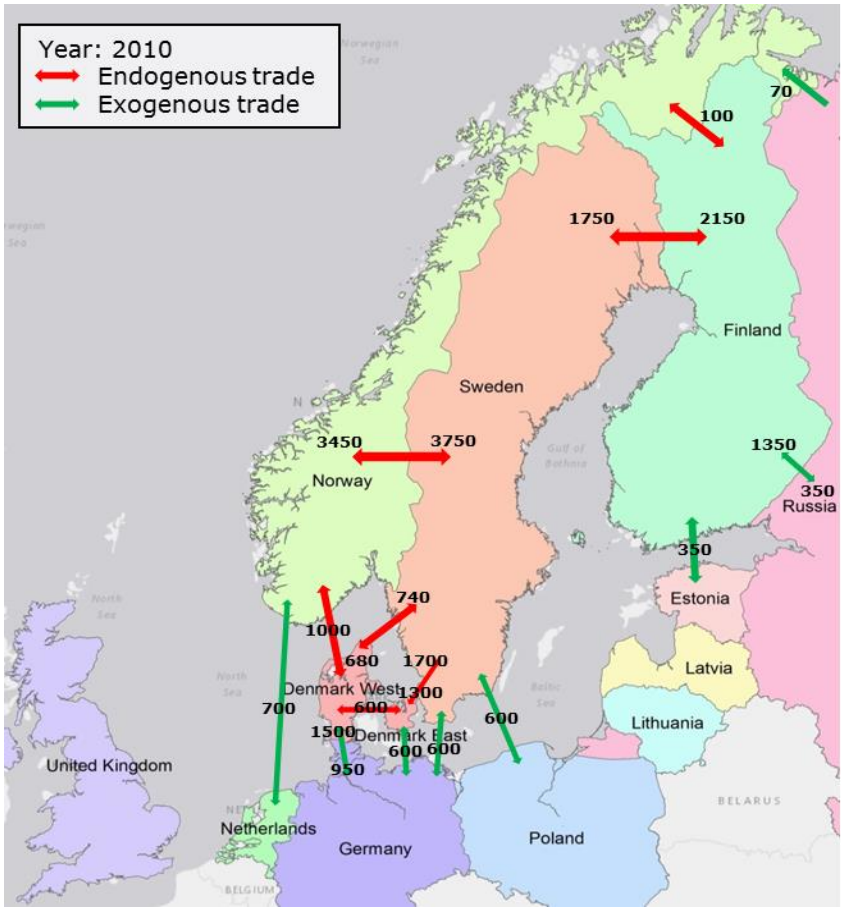


High integration of power systems

Source: ENTSO-E (2012)

Transmission grid expansion

Starting grid



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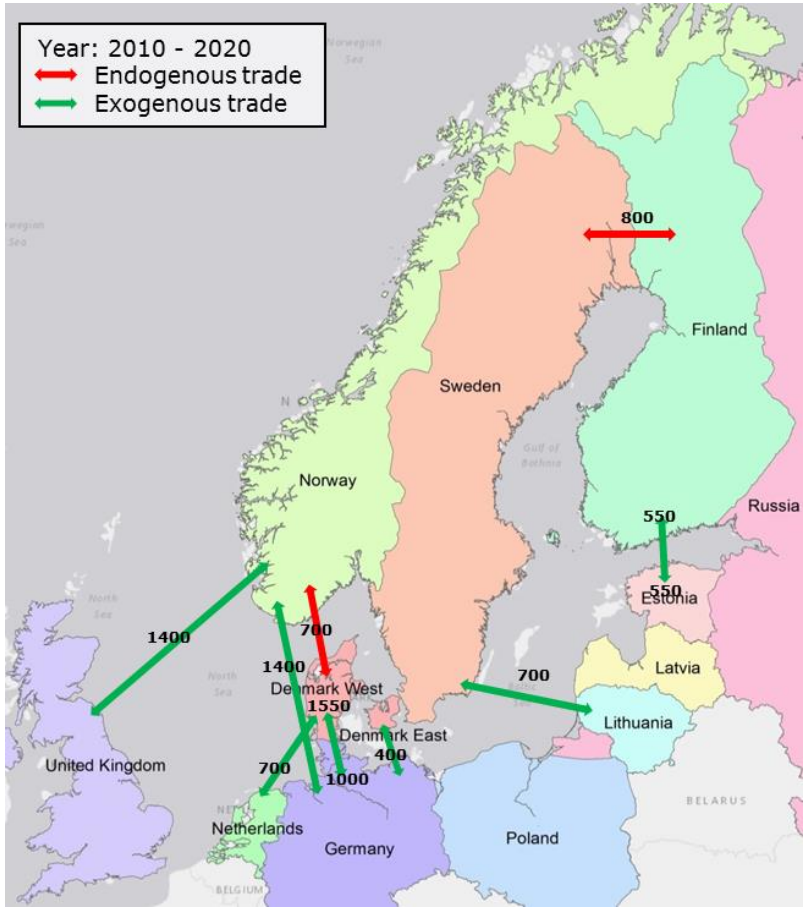
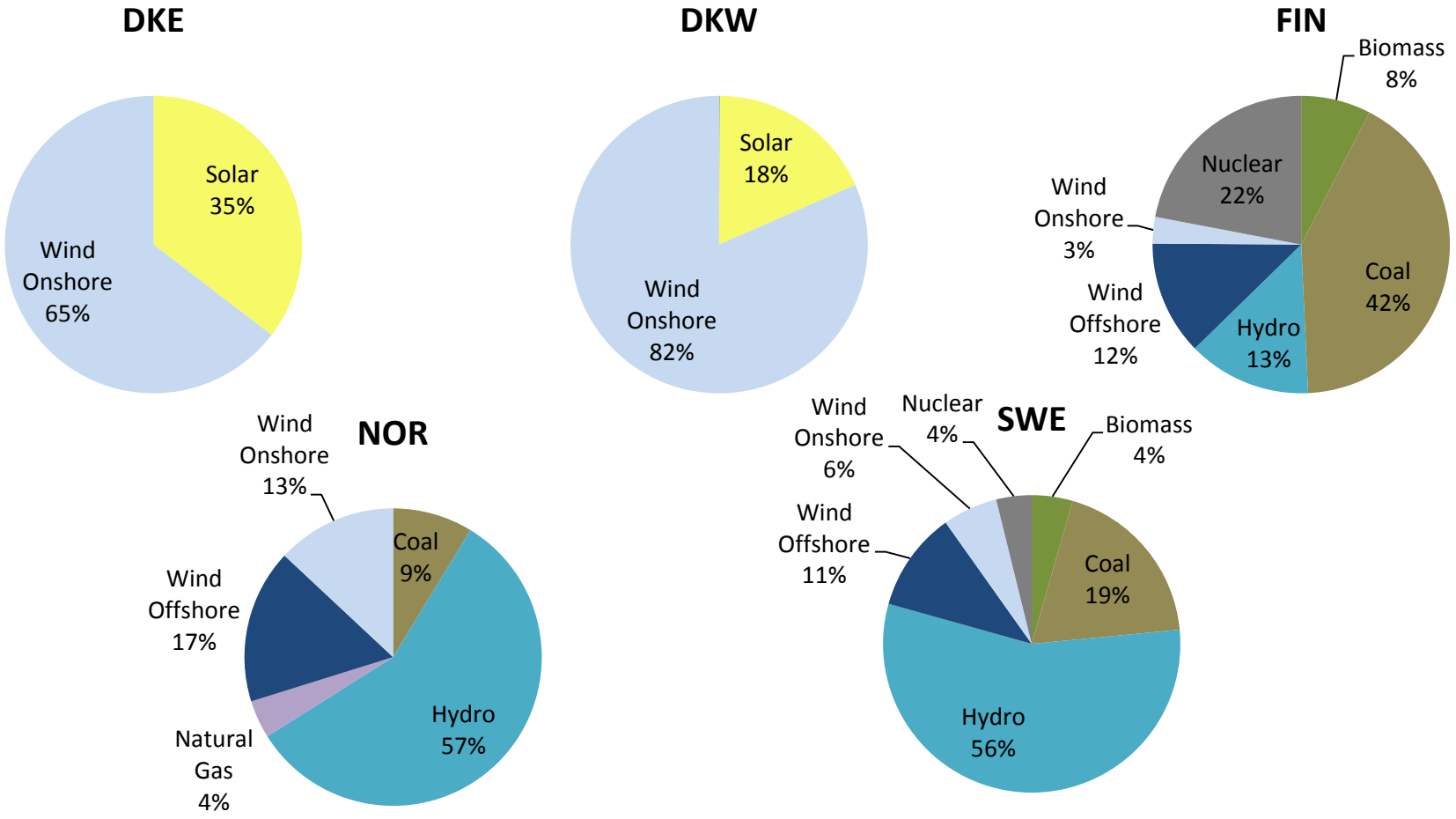
Exogenous grid expansion

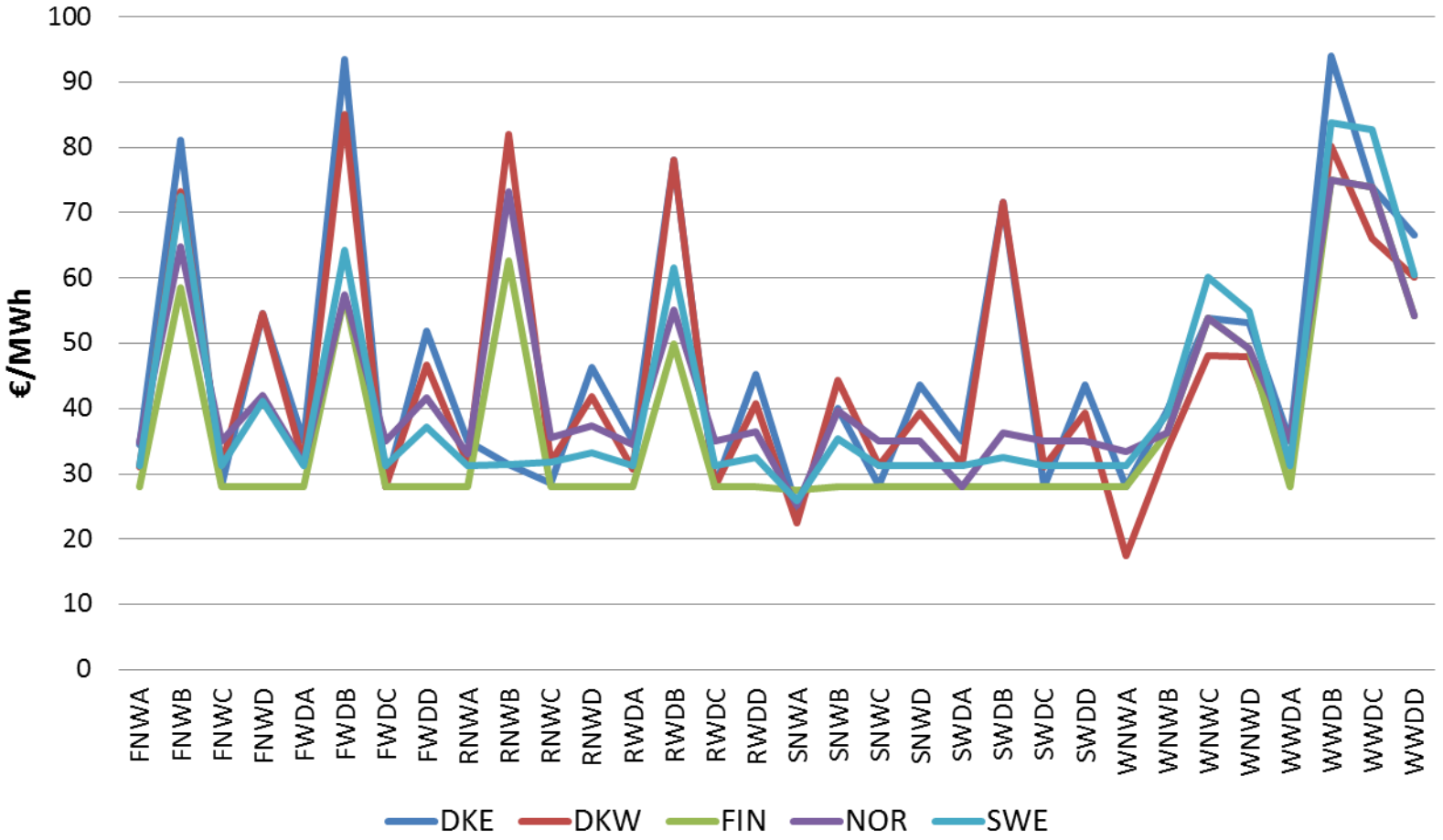


Source: ENTSO-E (2014)

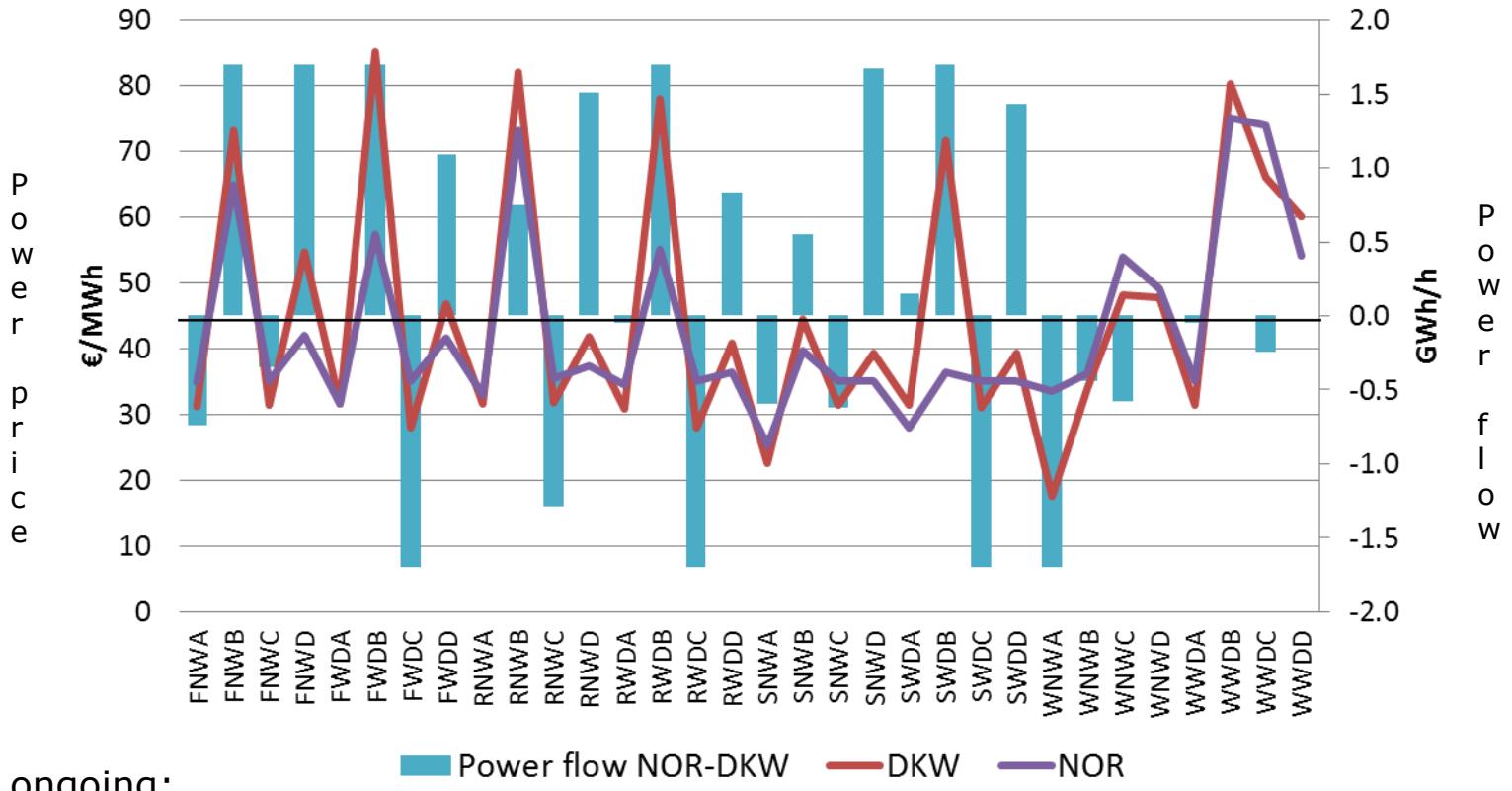
Power generation in 2050



Electricity prices in 2050



Power trade between Norway and Denmark in 2050

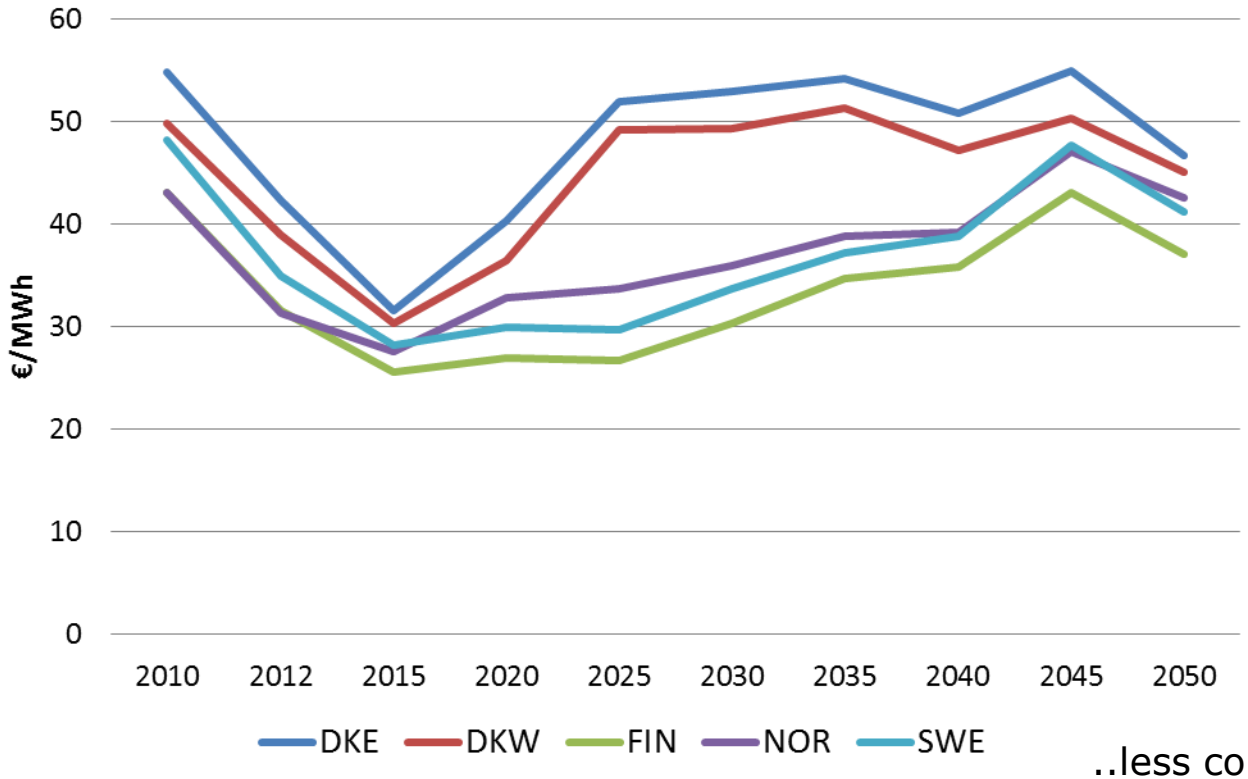


Trade is ongoing:

- Until marginal costs equal
- Until congestion occurs

Price convergence

Between 2010 and 2020 about 7.5 GW of new transmission lines are installed



..less congestions

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Analysis of grid expansion

- Uncertainty on grid expansion after 2020
- Endogenous optimization of grid expansion
- Possible new interconnectors from ENTSO-E in Ten-Year Network Development Plan 2014 (TYNDP)
- Constraint on starting year, no on transmission capacity

entsoe
Reliable Sustainable Connected

Uncertainty on costs of future interconnectors

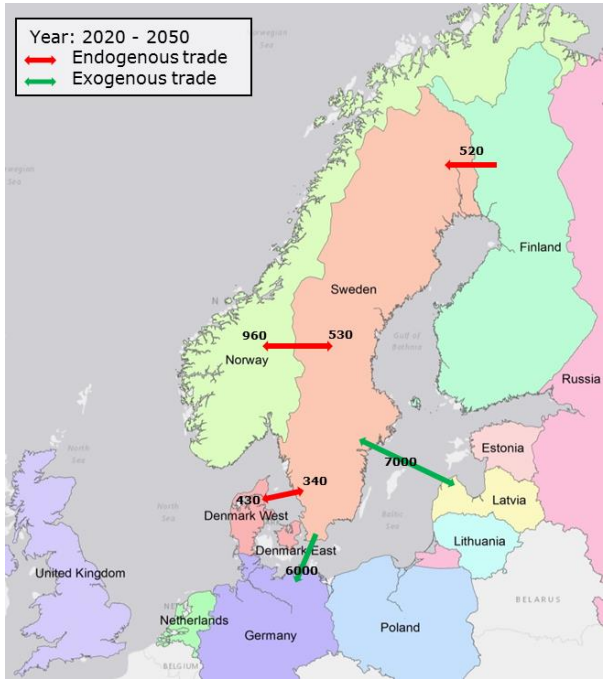
	Low		Medium		High	
k€/MW	INVCOST	O&M	INVCOST	O&M	INVCOST	O&M
NOR-SWE	190	0.4	310	0.7	440	1.0
NOR-FIN	600	1.4	1000	2.3	1400	3.2
SWE-FIN	56	0.1	91	0.2	130	0.3
DKW-DKE	430	1.0	725	1.6	1020	2.3
DKW-SWE	560	1.3	930	2.1	1300	2.9
SWE-GER	260	0.6	429	1.0	600	1.4
SWE-LAT	300	0.7	500	1.1	700	1.6
NOR-HOL	1033	2.3	1721	4.0	2410	5.4

Source: ENTSO-E (2014)

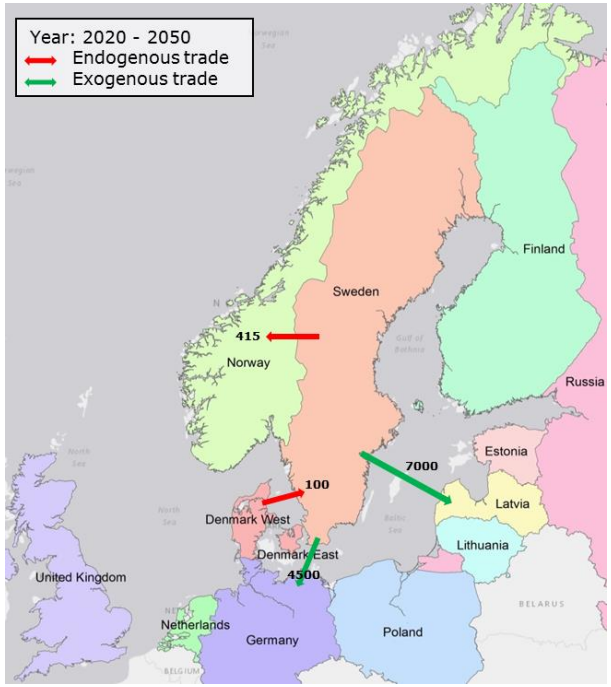
Sensitivity analysis with interconnectors costs: under which cost condition the interconnectors are built?

Endogenous grid expansion: sensitivity analysis

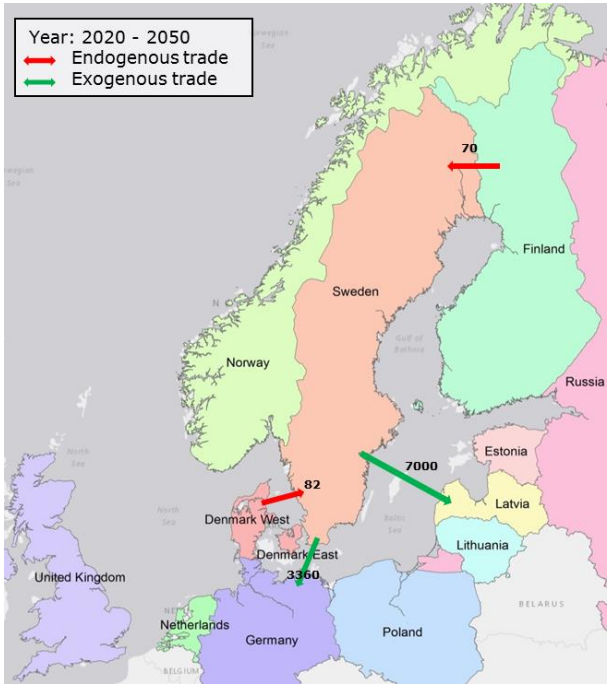
Low interconnectors costs



Medium interconnectors costs



High interconnectors costs



Exogenous power prices not consistent

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Sensitivity analysis: only existing interconnectors

How does the Nordic power system react to a changeless transmission grid?

Only interconnectors existing or under construction by 2015 are considered

Region	Average relative price increase	Average absolute price increase (€/MWh)	Price relative stnrd dev increase
DKE	7%	3.4	59%
DKW	1%	0.5	64%
FIN	1%	0.5	53%
NOR	9%	3.9	88%
SWE	12%	4.8	87%

Most penalized country

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Conclusions

TIMES-NPM hard-linked to TIMES-DK allows:

- Calculating endogenously the power prices and volumes between Denmark and the rest of the Nordic countries → Limiting the risk of the assumptions on the exogenous trade processess for the Danish interconnectors

- Optimizing endogenously the transmission grid expansion

- Assessing for the Nordic interconnectors the cost thresholds within which they are feasible

- Assessing for each Nordic country the average increase of power prices if the planned interconnectors are not built

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